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CAULIFLOWER PRODUCTION IN CALIFORNIA

H. A. JONES[1] AND F. H. ERNST[2]

FOREWORD

Cauliflower is a crop of economic importance in California. The principal districts center around the cities of San Francisco and Los Angeles. In the southern part of the State, the counties engaged in cauliflower production include Los Angeles, Orange, San Diego, Ventura, and Santa Barbara. Of these, Los Angeles County is by far the heaviest producer. In the north, San Mateo, San Francisco, and Alameda counties are the most important, although Santa Clara, San Benito, and Monterey counties produce rather large amounts. Because of the high price of land near the large centers of population, there has been a tendency during recent years to plant cauliflower in new districts farther removed. As a consequence, a number of experimental plantings have been made in different parts of the State, especially along the coast. It is a natural thing to expect considerable shifting in the production centers, therefore, as new and suitable areas are found for growing cauliflower.

Cauliflower is not one of the easiest crops to produce. It requires close personal supervision and congenial climatic and soil conditions. As yet, the crop in California has no serious diseases. A number of insect pests, most of which are easily controlled, sometimes cause damage. So far, the chief problem of the cauliflower grower has been that of acquiring good seed. Since the industry is a highly specialized one, the individual who grows cauliflower consistently year after year will find it more profitable, as a rule, than one who produces it intermittently.

That the California cauliflower industry increased rapidly from 1915 to 1921 was largely due to improved transportation facilities. Since 1921, however, the rate of increase has been less marked.

Most of the cauliflower grown for shipment is produced in California, New York, Oregon, and Colorado. New York has always grown a large amount but only during recent years, as may be noted in table 1, have Oregon and Colorado come to the front. Since 1922, cauliflower production has had a great stimulus in Colorado.

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SHIPPING SEASONS

The bulk of the California crop is shipped from October to April, inclusive. Cauliflower from northern California moves from November to March, while that from the southern district moves mainly from October to May. Most of the crop from the latter districts, however, is shipped during November, December, January, and February. That from the Central District moves from November to May with the greatest shipments during December, January, February, and March.

TABLE 1

CARLOT SHIPMENTS OF CAULIFLOWER FOR THE DIFFERENT STATES FOR THE YEARS 1921–1926, INCLUSIVE. (Bureau Agricultural Economics)

	1921	1922	1923	1924	1925	1926*
Total, all States	3,895	3,391	4,695	4,466	5,280	6,558
California	3,203	3,137	3,575	3,150	3,850	3,784
Colorado	2	4	101	29	191	199
Michigan	4	1	34	66	.....	.....
Minnesota	5	3	18	6	21	13
New Mexico	.....	.....	8	35	18	.....
New York	471	683	653	696	834	1,019
Oregon	83	133	277	415	333	1,436
Texas	.....	.....	.....	3	2	15
Utah	.....	1	.....	3	6	12
Virginia	14	15	13	37	12	30
Washington	1	.....	1	2	9	47
Wisconsin	.....	11	.....	.....	.....	.....

* Subject to revision.

The two states competing with the California product on the eastern markets are Oregon and New York. The Oregon spring crop is shipped during February, March, and April, and its fall crop mainly during October and November. The New York crop moves from August to December, thus competing with the fall shipments from California. The markets of the country are usually very well supplied with cauliflower from September to March. If districts able to produce cauliflower after March could be found, no doubt a ready market would be available. Table 2 gives the carlot shipments of Cauliflower, by months, for the entire United States; table 3 gives the same information for California.

These tables offer a good indication also of the shipping season for the California product as well as of the main producing seasons for the entire country. In California, the seasons vary considerably from

year to year. If the fall is warm and moist, the crop usually starts moving much earlier than when it has been cold and dry. If the weather during mid- and late-winter is warm, the crop matures so much more rapidly that fewer late shipments are made than during a cool spring.

As shown in table 1, California in 1926 shipped 3850 carloads of cauliflower, 5280 being the output for the entire country. In other words, 70 per cent of the carlot shipments for that year originated in California, while in 1925 they amounted to 73 per cent. These figures do not take into consideration the amount consumed locally or that shipped in mixed cars. Though most of the cauliflower sent from California goes in straight cars, a considerable quantity is also moved in mixed cars to centers of small consumption.

TABLE 2

CARLOT SHIPMENTS OF CAULIFLOWER BY MONTHS FOR THE UNITED STATES, 1921–1926

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1921	654	516	782	7	22	2	.....	13	171	493	631	604
1922	580	544	1,046	219	27	17	.....	22	150	320	283	783
1923	1,142	698	965	191	34	20	7	41	123	464	621	389
1924	623	975	777	161	108	16	1	65	157	477	621	485
1925	838	822	484	215	96	6	20	270	521	531	479	1,006
1926*	881	1,094	1,604	245	57	23	6	103	207	1,005	825	508

* Subject to revision. Data from Bureau of Agricultural Economics.

TABLE 3

CARLOT SHIPMENTS OF CAULIFLOWER BY MONTHS FOR CALIFORNIA, 1921–1926

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1921	649	508	718	4	7	2	.....	13	44	185	476	597
1922	580	544	1,037	116	12	16	.....	4	11	14	65	738
1923	1,141	698	802	92	22	17	7	5	8	33	443	307
1924	618	872	591	83	81	6	.....	17	1	50	375	456
1925	838	818	429	213	84	5	4	5	4	127	348	977
1926*	877	897	840	235	44	.....	.....	6	1	45	363	476

* Subject to revision. Data from Bureau of Agricultural Economics.

TEMPERATURE AND MOISTURE REQUIREMENTS

Cauliflower develops best in those areas where the temperature during the latter part of the growing period is cool and uniform, and where fairly moist conditions prevail. For this reason, the growing of cauliflower is mainly localized in those areas where the climate

is tempered by large bodies of water, as in the coastal counties of California and Oregon, and on Long Island. Extremely low temperatures while the plant is young may cause it to "button" or head prematurely. Low temperatures delay maturity, reduce the size, and consequently lower the acre yield. Freezing of the curd or head impairs the carrying quality.

Hot weather during transplanting time may interfere with the rapid establishment of the plants in the field. If it occurs while curds are maturing, it often causes yellowing, riceyness, or fuzziness. High temperatures appear also to stimulate growth of the head leaves, and in many cases, causes them to appear through the top of the curd. The curd itself often grows so rapidly under these conditions that harvesting at the best stage of development is almost impossible, especially when large acreages are being handled. Areas subject to cool climatic conditions usually suffer smaller losses from over-maturity.

Cauliflower should always have a sufficient supply of moisture in the soil to insure a continuous and steady growth. It does not thrive in dry sections, especially if they are subject to extremes of temperature or to wind storms. This crop makes its best development in a moist atmosphere. Well distributed rainfall or carefully regulated irrigations are necessary for the successful production of this crop. These conditions help to produce maximum yields, large sizes, and good quality.

SOIL REQUIREMENTS

Cauliflower can be grown very successfully on a variety of soil types. Generally speaking, however, the soil selected should be fertile, of good physical condition, retentive of moisture, and well drained. Where a number of different soil types are available, the medium and heavy soils should be used for varieties that mature in the fall and spring, as they are cool and retain moisture well.

When it is to mature during the rainy season, the crop should be planted in sandy or silty soils. These are usually so well drained that harvesting can be done without puddling. Though such soils produce good crops during the rainy season, they make low yields when used for very early or very late plantings. Soils of very light texture should be used for cauliflower production only when they are abundantly supplied with organic matter, which increases the water-holding capacity and cuts down costs by decreasing the number of irrigations needed. In the case of heavier soils, the presence of organic matter facilitates aeration and water penetration.

Fig. 1.—Alkali tolerance of cauliflower. Cauliflower grows on all but the worst alkali spots.

SEED BED

Preparation.—In most of the commercial cauliflower-growing districts of California, the plants are started in the open field. Where possible, seeding is done in the field on a good sandy loam soil, of medium fertility. Land for the seed bed should be leveled and irrigated, then plowed, and put into a finely pulverized condition.

The two types of beds generally used are the sunken or panel bed, and the raised seed bed. Where the soil is light and porous and not subject to packing, sunken seed beds are preferable. The latter are prepared in long narrow lands, 12 to 16 feet wide, with small dikes or levees on each side to facilitate irrigation by flooding. One acre of land in panels will probably accommodate more plants than the same area in raised seed beds. Moreover, sunken beds have a minimum of surface exposed, and hence dry out more slowly than raised beds.

On the heavier types of soil that form a thick crust after irrigation, raised beds have usually been found more satisfactory, as they facilitate quick growth. These are similar to the beds used for the growing of lettuce. They are usually about 6 inches high and are approx-

imately 18 inches wide, with irrigation furrows between. Each bed has two rows of plants, which are spaced 10 to 12 inches apart.

Twelve to 15 pounds of seed are sufficient to sow one acre of seed bed. Experienced growers have found that one acre is sufficient for 20 to 25 acres of field planting. A surplus of plants should be grown, so that only the best and strongest ones need be used for transplanting. Plants which have been stunted by remaining in the seed bed too long head prematurely. A chart of the varieties and the dates of planting in the seed beds will help the grower to avoid confusion and mistakes at time of transplanting.

Fig. 2.—In the foreground is shown the wooden flume used formerly for the furrow system of irrigation. The overhead system is now being used for irrigation. E. D. McSweeney Ranch. El Monte, California.

Sowing Seeds.—Seed should be sown with a hand drill, sufficiently deep to be in contact with moist soil, but not deep enough to prevent the germinating seedlings from reaching the surface. One-half to three-fourths of an inch in depth is usually sufficient. In hot dry weather, the depth should be greater than in cool moist weather. The rows are spaced about 12 inches apart.

Planting Schedule.—In the centers of commercial production, it is very essential that the different varieties and strains be planted at the proper time. Experienced growers in the Los Angeles district claim that each variety has a definite limit in planting dates, beyond

which favorable results can not be secured, and that only varieties which have been developed for a particular season of the year should be used. In that district, Snowball, an early variety, is usually planted in the seed bed during the month of May. The various strains of the Pearl variety are seeded from May 15 to August 15. Some growers make plantings every ten days, beginning with the Early Pearl, and following this with the Half Early Pearl, the Late Pearl, and the Broccoli. The Early Pearl is usually sown from May 15 to June 15, and the Half Early Pearl from June 5 to July 1, sowings in each case being made every ten days. First sowings of the Late Pearl are made about June 25, and late ones come at ten-day intervals up to August 10. Broccoli is usually seeded about July 1, and at intervals of ten days up to August 15. In this way, a succession of crops is secured throughout the season, thus making harvesting a continuous operation when once begun.

Though different growers vary this planting procedure somewhat to suit their local conditions, their main object is to have a continuous harvest throughout the shipping season. A suggested planting program, as worked out by Mr. J. N. Teague of Arcadia for his conditions, is given herewith:

Early Pearl	May 15
Early Pearl	May 23
Early Pearl	May 31
Half Early Pearl	June 17
Half Early Pearl	June 19
Broccoli	June 19
Half Early Pearl	June 19
Broccoli	June 30
Broccoli	July 14
Broccoli	July 29

In districts having an equable climate with a mild winter and a cool spring, Late Pearl and Broccoli may be seeded as late as August 20. In this case, an extra late crop is secured, which comes off during April. In any case, plants should be started sufficiently early to reach a large size before the cool winter weather checks their growth.

In the Colma district, one variety of cauliflower and two varieties of broccoli are grown. The cauliflower grown in this district is not known by any specific name, and is seldom shipped, most of the product being sold locally. The White Broccoli is sown during June or July, while the Black Broccoli is usually sown in early July.

MANAGEMENT OF THE SEED BED

Care should be exercised to develop healthy stocky plants. If the seedlings are too thick in the row, they should be thinned to prevent overcrowding. Under the best soil and climatic conditions, and with a well prepared seed bed, it may be possible at times to produce good plants without the addition of irrigation water after the seed has been sown. The best growers irrigate only when absolutely necessary. An irrigation shortly before pulling the plants produces succulent roots, many of which die during transplanting. The shock of transplanting is less severe if the plants have been deprived of water somewhat and have been allowed to harden, than if they are in a tender, rapidly growing condition. If the soil is hard and the plants can not be pulled readily, the beds should be irrigated the day preceding pulling. It is best not to wet more of the plant bed than will be used the following day. However, if the soil is loose, this irrigation is unnecessary. Plants are usually of sufficient size for transplanting 6 to 9 weeks after seeding, depending upon the time of the year. Only the largest are removed at first. An irrigation should be given immediately after the first pulling to stimulate the growth of the remaining plants.

An effort should be made to secure a uniform continuous growth. If plants remain in the seed bed for too long a time, growth is severely checked and premature heading is often brought about. Soil which does not hold water well should be irrigated frequently enough to promote an even and normal growth. Water should be withheld about a week or ten days before pulling. Usually only two pullings should be made from a bed.

In some sections, especially in the northern and central coastal regions, the cauliflower and broccoli plants are started in more or less protected field beds, especially when grown during the late fall, winter, or early spring. In the Colma region, the beds are usually located on southern slopes where they are well protected from the wind. After being well manured, they are plowed, then finely pulverized and seeded. They are then covered with litter to prevent baking of the soil, especially during the drier part of the year. The beds are usually irrigated by overhead sprinklers with long slowly revolving arms, and are thinned and kept well weeded and cultivated. The plants are allowed to grow to a larger size before transplanting than is generally the custom in other sections.

PULLING PLANTS

A common practice is to pull plants during the fore part of the afternoon, and then the field having been prepared during the morning, to transplant with the same crew during the remainder of the day. The plants are sorted and packed in lug boxes, which are kept covered with moist burlap sacks. Only as many plants are pulled as can be transplanted the same day. The largest and stockiest plants are selected. If the leaves are very large, they may be trimmed to reduce the loss of water. Plants which are well hardened need very little, if any, cutting back of the leaves.

Fig. 3.—The above figure shows the size of plants that are used for transplanting, also the method of handling in lug boxes when transferring from nursery to the field. Los Angeles County.

LAYING OUT THE LAND FOR IRRIGATION

Rows should be run in such a way as to have enough fall to facilitate irrigation and surface drainage. Light soils which take water very rapidly should be laid out to give a uniform distribution of water throughout the length of the furrow. This may necessitate short runs of 200 to 400 feet, which generally give more rapid irrigation. The ditches and furrows should be laid out in the direction to give the desired fall. If, however, the soil does not absorb water readily,

they should be run in the direction which will give a minimum fall, in order to get a uniform penetration of moisture. Runs in this case may be as long as 600 feet. There should be no waste water except on lands of very steep slopes, and that from the higher levels should be used to irrigate the lower. While cauliflower is commonly grown on side hills in the northern and central cauliflower districts, steep grades are undesirable, especially in the warmer and dried regions of the state. In the latter areas, it is very desirable that the land be well graded to a moderate slope so that the water can be applied uniformly. If this is not done, certain areas of the field are flooded at the time of irrigation, while others remain high and dry. Leveling should be done well in advance of the planting season. If much soil has been moved, it is best to make a test irrigation to settle the soil and reveal the depressions and elevations. The necessary retouching can be done after the land has become sufficiently dry.

PREPARATION OF THE LAND

If cauliflower follows beans in rotation, the land should be chiseled as there may not be sufficient time for plowing. This is less expensive, requires less time, and does not turn up clods.

Furrows are usually made with a lister. They should be spaced a uniform distance apart throughout their entire length to facilitate cultivation. In the application of water for furrow irrigation, head ditches are commonly used. These should have sufficient capacity to irrigate adequately and quickly.

PLANTING

After the plants are pulled, every effort should be made to get them into the ground as soon as possible. They are dropped in the furrows just ahead of the person planting, and are then set in the bottom of the furrows with short handled hoes.

On soils which are light to medium in texture, planting in the furrow bottom is especially desirable; on very heavy types, the side of the furrow is often used. Plants should be set so that they will stand up, and not be submerged with the irrigation water. Whatever replanting is necessary, should be done as soon as possible. Rows should be 34 to 36 inches apart and plants about 24 to 30 inches apart in the row, depending upon the variety. Crowding should be avoided, as it reduces the size of the curd. The aim of the grower should be to produce curds of a medium-large size (12 to the crate), for which there is usually a good demand.

Fig. 4.—Plants set on the side of the ridge.

IRRIGATION

If the soil is dry, open, and porous, it may take a long time to get the water through, and the plants may suffer as a consequence. Under these conditions, a preliminary irrigation may be given before transplanting. When dry soil is used, it is very desirable to have the water applied almost immediately after the plants have been set. Where the rows are long, the water may be started as soon as the planter has set twenty-five to fifty plants and may be allowed to follow slowly down the row so as to prevent any excessive drying out or wilting.

During the summer and early fall, the plants are making a rapid growth and, therefore, require considerable moisture. Some growers in the southern cauliflower districts count on about five irrigations during the season. The number needed, however, varies with the different types of soil and with weather conditions. While cauliflower is naturally a shallow-rooted plant, surface rooting should not be encouraged by frequent light irrigations, especially during the early life of the plant. During the winter, rains may occur, but these should not be depended upon unless they are thorough enough to make an irrigation unnecessary. The chief object should be to keep the soil sufficiently moist to a depth of 3 or 4 feet throughout the life of the plant to secure a uniform and steady growth.

The number of furrows irrigated at one time depends upon the method of irrigations, the head of water, and the soil type. If the furrows have a pronounced fall, the water may be run in small streams. The operator may gauge the penetration of the soil moisture very

easily and accurately by means of a soil auger. The amount of water, or size of head used, should be gauged so that the water will reach the end of the furrow without too much waste.

Much interest is being shown in overhead irrigation. This method accomplishes a number of things not possible with furrow irrigation. It moistens all of the soil uniformly, reduces aphis damage to a minimum, and seems to produce a uniform and steady growth.

Fig. 5.—The photograph above was taken three days after planting and irrigating. Note how the plants have been revived.

The experimental sprinkler system on the E. D. McSweeny ranch, at El Monte, is capable of throwing about one acre-inch every twelve hours. Each unit is about 400 feet long and ½ acre in size. A comparison of cauliflower plots which had been furrow-irrigated with those which had been sprinkled showed the latter to be considerably more vigorous and thrifty in growth. Whether the yields are increased sufficiently to justify the installation of a sprinkler system is very problematical, especially when large acreages of cauliflower are grown. Overhead irrigation, however, should prove especially advantageous on hillsides, where satisfactory furrow irrigation is difficult.[3]

[3] Directions for installation of overhead irrigation are given in Wadsworth, H. A. Irrigation by overhead sprinkling. California Agr. Ext. Serv. Cir. 4. 37 p. 12 fig. 1926.

CULTIVATION

Cultivation usually follows each irrigation except, possibly, the last two or three. About five cultivations are required during the season. If it is possible to perform these at the proper time, hoeing is reduced to a minimum and may be entirely unnecessary. When the furrows are filled, the weeds are covered and killed. Cultivation and preparation for irrigation are usually accomplished in one operation by attaching a large shovel at the rear of the cultivator. During the later stages of growth, cultivation should be shallow, so as not to destroy any of the surface roots. The last cultivation levels the soil between the rows and gives a smooth surface, thus making harvesting much easier.

SOIL IMPROVEMENT

The soil must be sufficiently fertile to produce a plant of good size. A large curd can not be obtained from a small plant. The plant food elements should be present in available form and in sufficient amount to give a continuous growth. While phosphorus, potash, and other plant food elements are necessary, the one most generally needed is nitrogen.

Crop Rotation.—It is always advisable to carry on some type of crop rotation. Cauliflower diseases as well as insects accumulate in the soil and infect and injure in increasig amount the succeeding crops. Planting cauliflower continuously on the same land, therefore, is undesirable. In southern California, it is usually grown as a fall and winter crop, following spring and summer crops. It is also often grown in rotation with early potatoes, sweet corn, early tomatoes and spring lettuce, less often with beans and carrots. Alfalfa is frequently used in a long rotation.

Intercropping.—In Los Angeles County, some cauliflower is grown as an intercrop among deciduous fruit and English walnut trees. If the trees are large, the cauliflower crop can be planted so as to have the maximum growth period at a time when the trees are bare. Extreme shading will not then occur.

Manuring.—There is considerable difference of opinion among growers as to the value of the various fertilizers. Many of the more successful growers have large supplies of barnyard manure available.

Cauliflower fits in well with dairying; and an abundant supply of manure may thus be obtained. Where livestock is kept on the same farm, the task of maintaining the soil in a highly productive condition is not a difficult one. Ten to twenty tons of manure may be considered a good annual application. If fresh manure is used, it should be applied and disked or plowed under in time to allow it partially to decompose before the crop is planted. Besides supplying plant food, it increases the organic matter in the soil.

Green Manure Crops.—If manure can not be obtained in sufficient amount to supply the needed organic matter and plant food, green manure crops alone or with commercial fertilizer may be used. The cover crop or green manure crop, preferably a legume, chosen should be adapted to the local climatic conditions and should produce a good tonnage of vegetable matter. It is better to grow green manure crops to plow under, rather than to allow the fields to lie idle during a part of the year. Such crops keep down weeds and help conserve the soluble mineral elements of the soil, especially in regions of heavy winter rainfall. They prevent erosion, help aerate the subsoil, and increase the favorable bacterial flora of the soil. By the addition of organic matter, the texture of heavy soils is improved and the moisture-holding capacity of the sandy ones is increased. Where nematodes are prevalent, crops or varieties resistant to their attack should be grown.

Cowpeas and Taredo soybeans are good green manure crops to grow during the summer where temperatures are moderately high. Many of the best growers plant such crops at least once every two years. Melilotus indica and purple vetch are common ones used. The former is probably the more popular. It may be seeded when the cauliflower is disked up and then plowed under when again preparing for cauliflower. By doing this the only expense for cover cropping is the seed and the water.

Commercial Fertilizer.—In certain cauliflower sections, the high price of land prohibits the planting of green manure crops, and the productivity of the soil, therefore, must be maintained largely by the use of commercial fertilizers. The three constituents supplied in a complete fertilizer are nitrogen, phosphorus, and potash. Any of these may be supplied in the organic or inorganic form. In the latter form, the elements are immediately available to the plant, while in the former, the complex compounds must undergo decomposition into more simple forms before they can be absorbed by the plant. This decomposition or change is effected by different bacterial groups in

the soil. When the temperature of the soil is low, these bacteria function slowly or not at all, so it is better, during the cooler seasons at least, to apply a part of the fertilizers in the inorganic form.

It is impossible to specify a single kind or a uniform rate of application of fertilizer for the entire state or for any large district within the state. It is best for each grower to make a number of tests on his own farm to determine the kind to use and the most profitable amount to apply. In general, growers have found that it is the lack of nitrogen which limits the growth of the cauliflower plant. Nitrogenous fertilizers, therefore, usually give the greatest growth response. Nitrogen can be supplied in the inorganic form as nitrate of soda or sulphate of ammonia. Tankage, fish meal, cottonseed meal, dried blood, and other compounds can be used to supply the organic form. An application of about 70 to 80 pounds of nitrogen to the acre before planting should give good results. About half of this should be applied in the organic and half in the inorganic form. If the plants are making a slow growth or if they appear yellowish green, a side dressing of 100 to 150 pounds of nitrate of soda or sulphate of ammonia to the acre usually cause a quickening of the growth rate and a darkening of the leaves.

BLANCHING

The market demand is for a pure white curd. Varieties such as Snowball have a small amount of foliage, which neither covers the curd nor protects it from the sun and weather. To prevent discoloration, it is necessary, therefore, to gather together and tie the outside leaves over the head. Breaking the leaves over the head, a method sometimes used, is unsatisfactory, as the wind is likely to displace them. Moreover, if they decay, a yellowing of the curd results. When the curd is small, it is well protected by the small inner incurving leaves. As it increases in size, the leaves gradually lift, thus exposing the curd. To prevent discoloration, the outer leaves must be gathered together and tied while the small inner leaves still protect the head.

The length of time necessary for the development of the curds to a marketable condition after tying depends chiefly upon the temperature. During warm weather they may be ready for harvest within two or three days, but during the cooler part of the year, as long as two weeks may be required. All varieties of broccoli and some varieties of cauliflower are sufficiently protected until the curds are ready for harvest and, therefore, need not be tied. By far the greater part of the California crop is composed of the latter type.

HARVESTING

Every few days after the crop begins to mature, all heads in the proper stage of development are cut, trimmed, and hauled in a high-wheeled cart to the ends of the rows, where they are transferred to wagons or trucks to be hauled to the packing shed. The axles of the cauliflower cart are bent, thus elevating the bed so that it clears the top of the standing plants. This bed works on a hinge to facilitate the unloading. Four or five such carts are usually required for a field of sixty acres.

Fig. 6.—Small two-wheeled carts are pulled through the field into which the cauliflower heads are thrown. The heads are then transferred to wagons or trucks at the end of the field, and hauled to the packing shed.

The cauliflower head with the jacket leaves attached is severed from the plant with a large knife. A sufficient number of these jacket leaves are left on to give good protection. Many growers cut the stem to the desired length in the field so that it needs no further trimming at the time of packing. The tips of the leaves may be cut back at the time of harvest or may be left intact until the crate is packed.

It is imperative that the heads be cut while they are still compact. It is a common error to allow the head to get past its prime before

cutting. There is very little danger of cutting the heads before they have made the proper size. If the plants have not made good growth, the heads will not grow large, regardless of the length of time they remain in the field. It is generally considered a better policy to disregard the size feature at the time of harvest and consider only the stage of maturity.

Fig. 7.—Cauliflower head ready for market. The figure shows outside leaves trimmed off and the inner leaves left as a jacket to protect the edible parts.

One should always picture the appearance of the head at the time of arrival at market. Appearance is an important factor in the sale of any commodity, and even one over-mature head in a crate may spoil the appearance of the entire lot. Over-mature heads are very conspicuous because the advanced growth spreads the leaves and exposes the curd. Young ones are more concealed in their jacket leaves and, therefore, attract less attention.

Since cauliflower matures very rapidly in warm, rainy weather, a large portion of the crop may be lost unless additional labor is provided during these periods. If a part of the field has become over-mature, it is best to accept the loss and continue to cut only the desirable heads rather than to attempt to harvest those that have passed their best marketable condition. Occasionally during a rush period, the cauliflower heads are cut and left inverted in the field for a short time. This checks the growth and prevents losses that might otherwise occur.

Fig. 8.—Another view showing the ideal condition for cutting. This figure, also, illustrates how the inner incurving leaves of some varieties protect the developing curd from the sun and frost and keep it pure white in color.

GRADING

As has just been stated, the chief aim of the California grower should be to place a product of high quality on the market. The permanent success of the California cauliflower industry depends upon sending to the eastern markets a product rigidly graded and highly standardized. The inherent characteristics of cauliflower apparently make this vegetable more subject to transit deterioration than is the case with other vegetable crops shipped from California. Since much of the cauliflower shipped from California is sold on consignment, the price received is determined entirely by the appearance and quality of the pack. In many cases, growers suffer large differentials because one or two heads of poor quality are present in the inspected crates. At the present time, there is a good demand for cauliflower of high quality, but there is almost no market for poor stock.

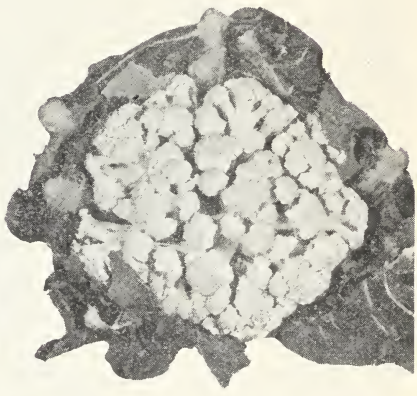
Over-maturity.—The stage of development of the head affects very markedly its carrying qualities. The longer the heads are left in the fields after they are ready to cut, the more wilted they appear when they reach the market. If the curd has begun to separate, as shown in figures 9 and 10, it deteriorates much faster than one compact at the time of cutting. If the heads are spread, they reach the eastern markets in an almost unsalable condition. Every effort, therefore, should be made at the time of cutting and again at the time of packing to discard all heads that are slightly spread, for this condition is usually much more pronounced by the time they reach their destination.

Fig. 9.—Cauliflower head very much over-mature. Curds of this age should not be harvested.

"Riciness."—A condition known as riciness is caused by the elongation of the ultimate branches. The head then becomes granular in appearance, as shown in figure 11, and is less compact than it should be. Although a ricey head is not as objectionable as one which is badly spread, it suffers some differential in price on the market. Riciness may be largely overcome by the selection of seed of good quality and by growing the crop under the most favorable climatic conditions. It is usually more likely to occur when the crop matures during exceptionally warm dry weather. It may also be brought about at times by allowing the heads to become slightly over-mature. However, heads may become badly spread without showing any signs of riciness.

COMPACT

SLIGHTLY SPREAD



BADLY SPREAD

Fig. 10.—The heads should arrive at destination in a solid condition, as shown by the compact head above. If the heads are cut and packed when only slightly over-mature, they spread considerably more before they reach the eastern markets and appear as the heads labelled "slightly spread" and "badly spread." The heads pictured are neither ricey nor fuzzy, but the badly spread and loose condition is especially objectionable.

"*Fuzziness.*"—When the individual flower stems or pedicels elongate, the head assumes a velvety or fuzzy appearance such as that shown in figure 12. The entire head or only a small portion of it may be so affected. Some varieties are more predisposed than others to fuzziness. This condition is usually brought about by adverse growing conditions, sometimes by slight over-maturity of the heads. It can be overcome to a great extent by observing the same precautions as for riciness.

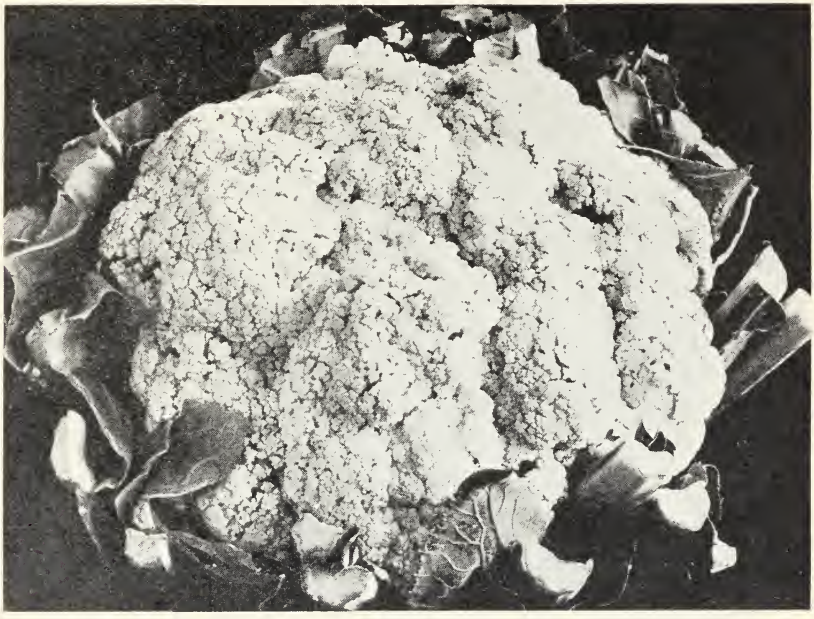


Fig. 11.—Ricey head of cauliflower. (New Jersey Agr. Exp. Sta. Bul. 432.)

Leafy Curds.—Leafy curds are those which have small green leaves appearing between the segments. Curds of this type are undesirable, and if possessing many leaflets, should be discarded. This condition is usually due to seed of poor quality.

Small Sizes.—Small sizes usually mean a lower price to the crate as well as fewer crates to the acre. Usually, small sizes are the result of growing the crop on unproductive soil, or of getting the plants started too late in the fall. For winter and early spring crops, the plants should be set in the field in time to secure a good growth before cold weather.

Color of Leaves.—When the heads reach the eastern markets, the jacket leaves should be green—not yellow in color. If subject to high temperature after cutting, they will turn yellow and drop during transit or after reaching destination.

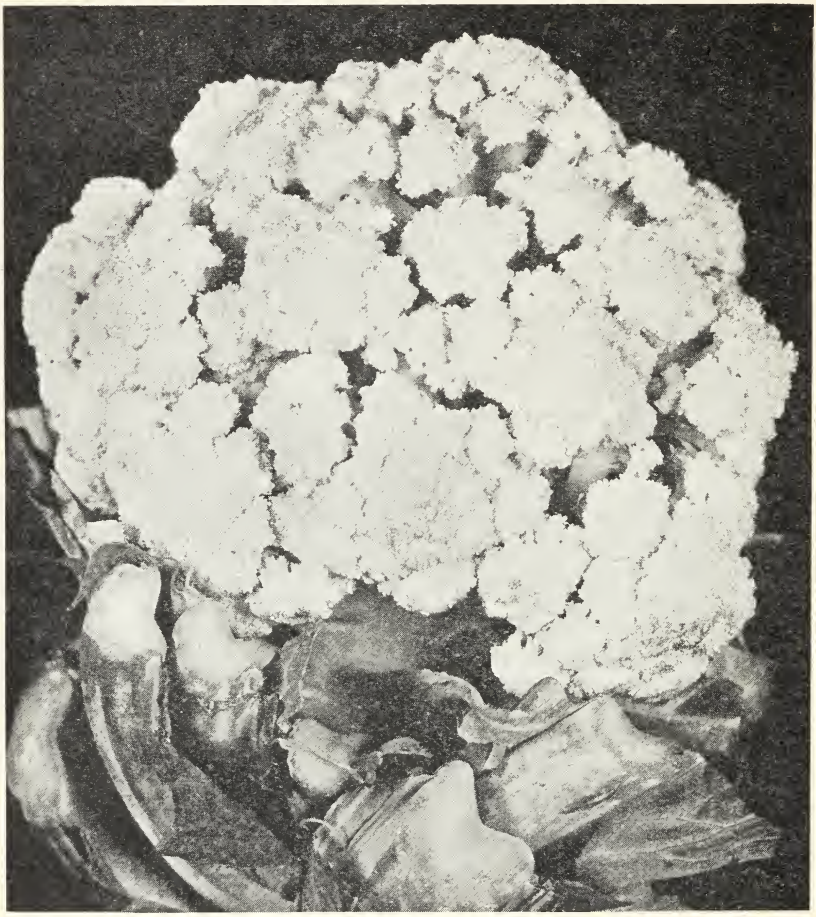


Fig. 12.—A fuzzy head of cauliflower. The pedicels or stalks of the individual flowers have started to elongate. This condition may accompany overmaturity but is usually prevalent when the crop has been grown under unfavorable climatic conditions.

Discoloration of Curd.—Curds which are exposed to the sun develop a brown pigment that is very objectionable. Varieties such as Snowball should have the leaves well tied over the head to prevent discoloration. If the plants are not to be tied, only those varieties and strains should be grown which have their heads naturally well

protected. The surface of the curd becomes discolored also if bruised. If possible, the curd should not be touched during the harvesting and packing operations.

Insect Injury.—Occasionally worm injury reduces the salability of the product. Heads having a large portion of the leaf blades eaten or having deposits of green excrement in the white curd present a poor appearance on the market. The presence of aphis on the leaves at the time of packing is also objectionable, for during transit they may migrate to the surface and between the branches of the curd.

Fig. 13.—Leafy head. Heads which have a considerable number of small leaves appearing between the segments of the head as shown above should be discarded.

STANDARDIZATION AND PACKING

As the grades for cauliflower are subject to change without notice, they are not given here. They can be obtained from the State Department of Agriculture at Sacrmento or from the Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D.C.

The standardized pack, which most buyers prefer, can be made up better at the central packing houses where skilled men do the sorting than on the individual ranches.

Cauliflower is packed mainly in pony crates or flats, with only one layer of heads in a container. The heads are set erect in the crate, as

shown in figure 14; the foliage is trimmed to a bulge of 1½ to 2 inches, and then three narrow slats are nailed across the top. The crates are inverted in the car so that the melting ice water will trickle down over the leaves rather than collect in the heads.

Fig. 14.—After packing the leaves are trimmed to a bulge of about 1½ inches. The top slats are then nailed on.

LOADING

The main system now used in the loading of cars is known as the pigeon-hole method. By this method, 480 pony crates are placed in a car. As shown in figure 15, the third and fifth layers from the bottom are only 4 crates wide; between the crates of these layers are placed chunks of ice weighing from 10 to 20 pounds each. Strips of wood are nailed to the crates to prevent movement in the car. Ice is then

placed between the crates, on top of the load, and in the bunkers. The ice on top of the crates is usually left in large blocks weighing 30 to 40 pounds. The amount of ice used at time of loading varies with the season of the year. As a rule, the product reaches the eastern market in a better condition when the pigeon hole method of loading is used than when the shipments are made "sold-pack."

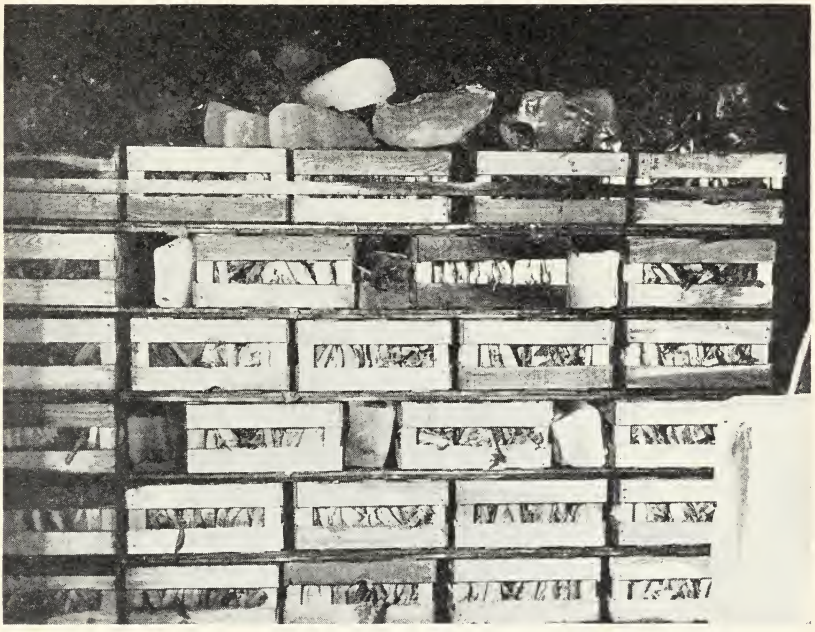


Fig. 15.—Pigeon-hole method of loading. Crates are inverted to prevent collection of water in the head. Blocks of ice are placed in the tunnels, on top of the load and also in the bunkers. A car loaded as above holds 480 pony crates.

SEED GROWING

As a general thing, the production of seed by the average grower is not to be recommended, because of the insufficient care used in the selection of seed stock and in rogueing out the undesirable plants. Although a considerable amount has always been produced by the commercial growers of California, so far as is known, no one has made a special effort to improve the stock. As a result, in those regions where cauliflower is an important commercial crop, opportunity awaits anyone who will make a specialty of breeding strains of higher quality and greater uniformity.

Some growers producing seed reserve several well rogued rows on one side of the field for seed purposes. Only the best curds in these

rows are allowed to develop. When this method is followed, selected plants only should be permitted to come into bloom. Often neighboring plants too poor to cut for market are unintentionally allowed to bloom. These cross readily with the selected plants, and the progeny are usually worthless. Fields which are being grown for seed should be at least one-half mile apart. Since the flowers are mostly insect pollinated, the greater the distance between fields, the less the danger of cross pollination. Since cauliflower and all varieties of cabbage, kale, Brussels sprouts, and kohl rabi cross freely, these crops should not be grown in close proximity for seed purposes.

Fig. 16.—Solid pack. The car when loaded holds 500 pony crates. There are five tiers the width of the car. Two tiers at each end have 7 layers and the remaining 12 tiers have 6 layers of crates. Ice is placed on top of the load.

It is sometimes necessary to cover the maturing plants with mosquito netting, as shown in figure 18, so that the birds can not break open the pods and eat the seed. When the pods are brown in color, the plants are cut and laid on large canvas sheets to dry. In two or three weeks, the seeds can be rolled with a large iron or wooden roller or threshed out with a flail. The seed is then cleaned and placed in burlap sacks. These sacks are only partially filled so that they may be turned every day for about two weeks and the seed cured thoroughly.

The best means of obtaining good seed is to select a few of the most desirable plants in the field and cage them to prevent cross

pollination. A cage of considerable size is necessary. One measuring about four feet each way should be satisfactory. The frame should be made of wood and the covering of muslin should be of sufficiently fine mesh to keep out insects. It is best to have the sides of the cage held together by screws rather than nails. The screws can be taken

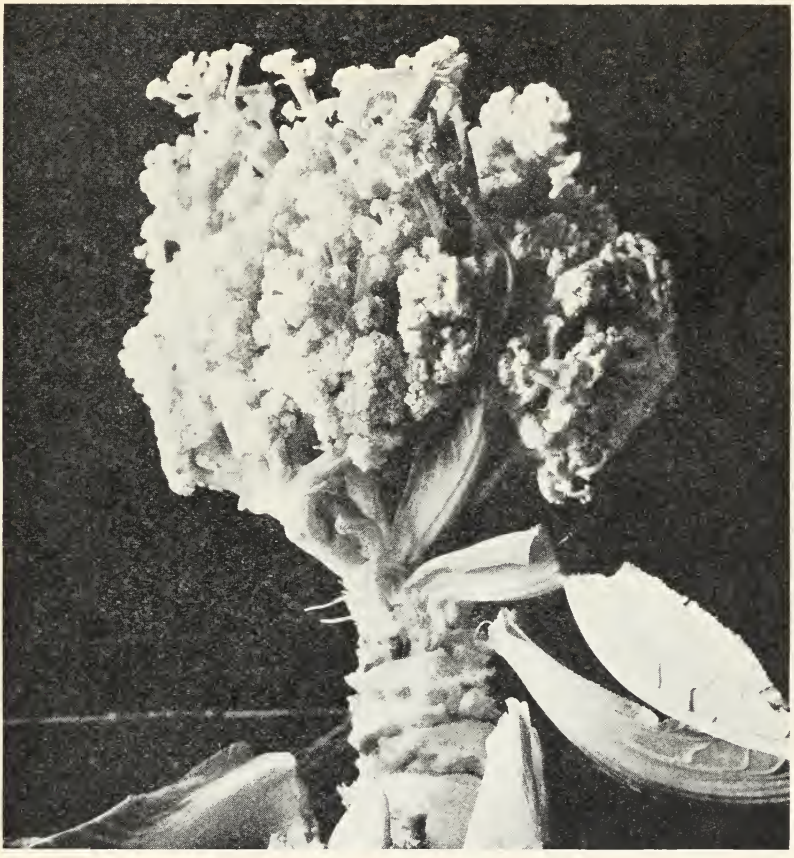


Fig. 17.—If the temperature of the car is high during transit, the cauliflower heads continue to grow and at times may push their branches through the crates. The head pictured above made considerable growth because of the high temperatures during transit.

out without breaking the boards and the cages stored in the knock-down form. The conditions within the cages are usually ideal for aphis attack, and if no precautions are taken, the plants may be entirely destroyed. Before being enclosed, the plant should be well sprayed or dusted to kill the aphis. If 25 or 30 ladybird beetles are then caged with each plant, there is little danger of aphis trouble.

If a few flies or other insects are enclosed within the cage, pollination is usually facilitated. A few insects of various species always hatch within the cage after the plant is enclosed.

The seed from each caged plant should be harvested separately and the selections planted side by side in parallel rows, where they can be compared. It is best to keep only one of the progeny lots; the remainder of the lots should be harvested and sent to market. A number of the best plants within the selected lots should be enclosed

Fig. 18.—After the seed has been set, it is necessary in some localities to cover the plants with mosquito netting for protection from the birds. This is especially advisable where only a few plants of extra good stock have been seeded.

again and the remainder of the lot left to open-pollinate and produce seed for the commercial crop the following year. By following this system, for a number of years, one should secure gradual improvement in uniformity and quality.

INSECTS

Cabbage Aphis.—A pest attacking the cauliflower plant very seriously at times is the cabbage aphis. It is present in all parts of the United States and is found living upon the wild and cultivated

members of the mustard family. These aphis have a whitish, mealy color. They are usually found on the under side of the older leaves and on the young succulent inner leaves. When the colonies appear on the edges of the leaf, they cause it to curl inward. They can often be detected by the appearance of yellowish spots on the leaves where the tissue has been injured. They lower the vitality of the plant by sucking out the juice. The cabbage aphis is kept under control to a certain extent by numerous parasitic enemies, which become most active as the weather becomes warm, and also by predaceous insects such as the ladybird beetles, and larvae and syrphus fly larvae. Hard driving rains also destroy many of these aphis.

Control Methods.—A good liquid spray for the control of cabbage aphis is made up of the following:

Nicotine sulphate (40 per cent)	1 pint
Fish oil soap	5 pounds
Water	100 gallons

As a general thing, it is rather difficult under field conditions to obtain a perfect kill with any liquid spray, because of the protection afforded by the leaves. An effort should be made, therefore, to reach the underside of all leaves, especially the central ones, for, to be effective, the spray must actually come into contact with the aphis.

Dusts containing nicotine sulphate are being used more and more for the control of the cabbage aphis. The dust can be blown into and about the plant so that the particles carrying the nicotine sulphate come into contact with every part. A dust containing 5 per cent of 40 per cent nicotine sulphate has been found to give the most satisfactory, and at the same time, the most economical control. The following formula makes a good dust: 95 pounds of hydrated lime plus 5 pounds of 40 per cent nicotine sulphate. Mixing should be thorough. Only an amount sufficient for immediate use should be made. Complete directions for the home mixing of nicotine sulphate dust is given in Farmers' Bulletin 1499. For cauliflower plants less than half grown, about 30 pounds of dust for each acre will be required; for more mature plants, about 50 pounds to the acre. When power dusters are used, long trailers should be attached as shown in figure 19 to hold the dust close to the ground and about the plants. Factory made dusts can be purchased from insecticide dealers.

It is often advisable at the time of transplanting to dip the plants in a soap-nicotine sulphate solution to guard against carrying lice into the field from the seed bed. The plants can be dipped and then placed in tight boxes until the time of transplanting.

As many of the wild mustards and other native crucifers are hosts to the cabbage aphis, they should be kept out of the fields and from the roadsides, fences, and other waste places.

Common Cabbage Worm.—The cabbage worm is one of the most serious pests with which the cauliflower grower has to contend. The damage is done by the larvae, which may consume entirely the succulent leaves of the young plant. When the attack is severe, often only a network of veins is left on the older plants. The eggs, which are deposited singly on either side of the leaf, are light greenish-yellow in color. The mature larvae are 1¼ inches long and a velvety green in color, while those overwintering are more of an ashen gray.

Fig. 19.—Dusting. The best aphis control is obtained in the seed bed and in the field, when a trailer is used behind the duster to hold the dust near the plants.

The adult is the common white butterfly, which is often seen flying over cabbage and cauliflower fields. The color and markings of the adult female are shown in figure 20.

Control Methods.—Arsenicals give the best control. These can be applied either as a spray or as a dust. The following formula gives a good liquid spray: 2 pounds of powdered lead arsenate, or 4 pounds of lead arsenate paste to 50 gallons of water. In order to make the spray adhere and spread out in a thin film over the leaves, 1 pound of laundry soap should be added to each 50 gallons of solution. The time to spray and the number of applications to be made depend

entirely upon the infestation. Some of the most serious infestations occur in the seed beds. Dusting with arsenicals is now being used almost exclusively for the control of the cabbage worm. *Dusting* with a mixture of 1 pound of powdered calcium arsenate and 8 to 10 pounds of air-slaked lime or gypsum gives excellent control. Dusting should start as soon as the moths or larvae make their appearance. Sometimes one or two applications at the proper time will be sufficient for the entire season. Again, it may be necessary to dust every 10 days or 2 weeks. The dust can be applied with a hand or power duster by shaking through a burlap sack or a tin can perforated at one end. It is best applied early in the morning while the dew is still on the plants.

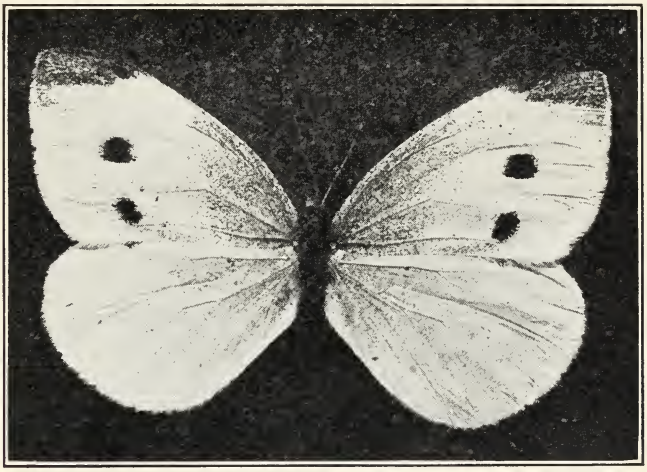


Fig. 20.—Female butterfly of the imported cabbage worm *Pontia rapae* (Linn) enlarged one and one-half times (after E. O. Essig).

Arsenical dusts or sprays must not be used after the head is formed, for it leaves a poisonous residue on the curd, which, if marketed, may be condemned and may subject the grower to prosecution by the health authorities. As the chrysalids may pass the winter on the old cauliflower stumps and other refuse in the field, the plants should be destroyed and the field plowed as soon as possible after the crop has been removed.

Cabbage Looper.—The larva of the cabbage looper is pale to dark green in color. When this insect is walking, the central part of the body forms a loop or arch. Though somewhat more difficult, control may be secured by the same methods as that given for the common cabbage worm.

Larva of the diamond-back moth may also cause injury at times. When mature, it is about three-tenths inch in length and pale green in color. It is active and very irritable. The control is the same as for the green cabbage worm.

Harlequin Cabbage Bugs.—The harlequin cabbage bugs are shining black or deep blue marked with brilliant orange or red. They are about one-half inch long and flattened. The eggs are laid in double rows, usually about a dozen eggs being present in one cluster. Both the adults and young suck the juice from the leaves; the affected parts then become yellow, wither, and die.

Control.—As it is rather difficult to control these insects with the ordinary contact insecticides, preventive measures must be used. Very good control can be secured when they first appear in the field, by dropping the adults into a can of kerosene. Since they are very sluggish, they can be caught with little effort. When observed, the egg masses should be picked and destroyed also. Where the insects are abundant, trap crops such as kale, and other brassicas, should be planted to precede the commercial crop. The insect can then be destroyed by spraying with kerosene. All weeds, especially those belonging to the mustard family, should be destroyed throughout the year. During the winter, they serve as a source of food and also as a means of protection for this pest. The nymphs can be killed by use of a 10 per cent kerosene emulsion, or a whale oil soap solution consisting of 2 pounds of soap to 4 gallons of water. These sprays are not effective against the adults.

Root Maggot.—It is during the larval stage that the root maggot does its destructive work. The adult flies lay their eggs on the stem of the cauliflower plant near the surface of the ground or on the soil in close proximity to the plant. The larvae are hatched within a few days, the length of time required depending largely upon the temperature. The young larvae migrate to the stem and to the roots below ground and there feed upon the roots, and often burrow the entire system below ground. The larvae or maggots are white in color and are about one-fourth inch in length when full grown. If the plant is badly infested, it wilts down and in the majority of cases does not recover. When the attack is light, about the only evidence is the slowing up in the rate of growth of the plant.

As the root maggot infests many of the mustard crops, such as radishes, turnips, cabbage, it is desirable to practice a rotation with crops not related to this group. The soil should be plowed and well cultivated during the late fall, winter, and early spring to expose and

destroy the pupae. In some sections, tarred paper disks have been used extensively to prevent the adult flies from depositing their eggs about the plant. When these disks are used, they should be applied at transplanting time or at least before the flies start to deposit their eggs.

Corrosive sublimate has been used for some time in England for the control of this pest and within recent years has come into general use in the United States and Canada. The first application must be made three or four days after transplanting; the second nine or ten days after transplanting; and the third, nineteen or twenty days after transplanting. One ounce of corrosive sublimate is dissolved in a small amount of hot water; sufficient water is then added to make 10 gallons. One-fourth teacup of this solution is poured about the stem of each plant at each treatment. Since this material is corrosive, it should not be mixed in metal containers but in wooden barrels or earthen containers. The cost of each application is eight to ten dollars an acre. Approximately 200 gallons an acre are required for each application.

DISEASES

Damping-off.—This is a seedling disease prevalent in the seed bed. The common symptom is a shriveling of the stem at the surface of the ground. The young plant then falls over and dies. This damping-off, which may be caused by a number of different fungi, is most prevalent in seed beds that are crowded, damp, and poorly ventilated. To control this disease, preventive rather than curative measures should be used. New soil should be used each year for the seed bed; if old soil must be used, it should first be sterilized. The light, well drained, sandy loam soils are better than the heavier types. The surface of the bed should be stirred frequently to facilitate drying and air circulation in the top soil. The bed should be located where plenty of sunlight and good circulation of air are available. The beds should not be watered on cloudy days; on bright days, they should be sprinkled early in the morning. Frequent light waterings are less desirable than thorough wettings at longer intervals. Seed should be sown in rows far enough apart to allow a good circulation of air about the plants and to permit the sun's rays to strike the soil. As a rule, the plants are subject to damping-off during their younger stages only. Cauliflower seedlings seem to be much more subject to the disease than cabbage seedlings.

Brown Rot.[4]—The brown rot of cauliflower is mainly a transit disease and develops most rapidly when the temperature and humidity are high. The disease causes a browning and spotting of the head which destroys its market value when the infections are numerous or severe. During most seasons, the disease is not sufficiently serious to justify control measures on the plants in the field other than seed bed and field rotation. At the time of packing, all the heads that show any brown or decayed spots should be discarded. Shipment should be made in good refrigerator cars so that the temperature of the cars during transit can be held at 42° F. or below.

ACKNOWLEDGMENTS

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[4] For more detailed discussion of brown rot of cauliflower see Weimer, J. L., Jour. Agr. Res. 29: 421–441. 1924.